Nuclear Science Program at the Massachusetts Institute of Technology

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Funding: FY2000: $5,951,000 FY2001: $5,591,000

Staffing:	Perm. Ph.D.[1]	Tech/Admin[2]	Postdocs[2]	Grad. Students[2]	Undergrads[2]
FY2000:	22	9	17	40	4

Research in nuclear science at MIT is carried out in the Department of Physics within the Laboratory for Nuclear Science (LNS). LNS, whose programs encompass experimental and theoretical research in nuclear and particle physics, is supported by a Cooperative Agreement with the Department of Energy. The experimental nuclear physics program includes research in medium-energy physics (with electromagnetic and hadronic probes) and in relativistic heavy ion physics. The MIT group leads the PHOBOS detector project at RHIC; the PHOBOS collaboration obtained and published the first data from RHIC. The theoretical program includes a broad range of topics in the phenomenology of QCD, plus a new initiative in large-scale lattice computation.

1. The centerpiece of the experimental program in medium-energy physics is the MIT-Bates Linear Accelerator, operated by MIT for DOE as a user facility. The Bates laboratory and its research program and budget will be described in a separate document. Research and development for a polarized electron – polarized ion collider, a major new initiative which has grown out of the physics at Bates, also will be discussed separately.

   A major new initiative in nuclear theory, led by MIT and the Jefferson Laboratory, has been proposed with the objective of understanding the structure and interactions of hadrons from first principles by solving QCD on a lattice. A national collaboration has been formed, with 24 theorists from 15 institutions working on hadron structure, spectroscopy, hadron interactions, fundamental aspects of QCD, and lattice field theory. Full lattice QCD with dynamical chiral fermions requires multi-Terascale computer resources. Lattice theorists in Europe and Japan already have dedicated use of 0.5-1 Tflops sustained operation. As part of a coherent national effort in lattice QCD, MIT and JLab are proposing clusters providing 0.5 Tflops in 2001-02, growing to 10 Tflops in 2003-05. MIT is strongly supportive of this effort, which represents an important opportunity to attract outstanding students and postdocs to this new thrust in nuclear theory. It is important that this initiative be pursued aggressively in order for the US to remain competitive with Europe and Japan.

[1] Includes faculty
[2] DOE-supported

2. In examining the budgets for the experimental and theoretical activities, one finds problems in nearly all areas. In relativistic heavy ion physics, the budget has been flat in as-spent dollars for the past five years. In real dollars this represents a decrease of about 10% over this period. The group has managed to function by situating all of its personnel off-campus for long periods to take advantage of the low overhead rate; this solution is neither desirable nor sustainable in the long run. Moreover, the number of people working on PHOBOS is too small for the size of the project; with MIT as the core of PHOBOS, the MIT group must expand in order for PHOBOS to continue to do timely, forefront research. At the current funding level, PHOBOS would cease to be competitive after a year or so. With an increase of 20% - 30% MIT can maintain its leadership in the heavy ion community. Roughly half of this increase is required in order for the students and postdocs to spend more of their time on the MIT campus, which would be beneficial both for them and for the MIT physics community, and the other half is required to strengthen the program.

   In medium-energy physics, the budgets have been "lean" for a number of years. The group is fortunate in that major research instruments such as OOPS and BLAST at Bates have been constructed with Bates funds. The development of a laser-driven polarized hydrogen and deuterium target for BLAST is supported by Haiyan Gao's OJI award. Personnel costs represent at least 80% of the budget, and it is vital that the current numbers of graduate students and postdocs be maintained or increased in order to capitalize on the investments in the facilities.

   In nuclear theory, the FY2001 funding level will not be adequate to support the expected expansion of the base program in 2002 and beyond. Two junior faculty are in the process of being promoted to tenure. A search is underway for a new assistant professor; several excellent candidates have been identified. The nuclear theory group intends to increase the number of postdocs from 4 to 5 and the number of graduate students from 6 to 10. An increase of about 20% over the FY2001 funding will be required to sustain these activities. The presence of Frank Wilczek (supported by the high-energy physics program) has led to increased effort in nuclear physics, with however no corresponding increase in funding between FY00 and FY01.

   The costs to MIT associated with the Lattice QCD Initiative will grow from $520K in FY01 to $910K in FY02 to $1160K in FY03. It is hoped that considerable funding will come from SCiDAC (Scientific Discovery from Advanced Computation), but the nuclear physics program may need to contribute, especially in the early years, to make the project viable.

3. The presence of a major university-based research facility (Bates) has allowed MIT to attract excellent young faculty, postdocs, and students. Although Bates is the focus of MIT's research activities in medium-energy physics, MIT group members have also carried out experimental programs at several other facilities: Jefferson Laboratory, DESY (HERMES), the Mainz Microtron, the Los Alamos Neutron Science Center. In the past, group members have worked at LAMPF, PSI, SLAC, and IUCF. Though varying from person to person, as new people with different spectra of interests join the group and new opportunities arise, the overall balance of research effort has been roughly constant for the past five years at about 50% at Bates and 50% elsewhere. We do not anticipate a significant change in this pattern in the years to come. The MIT group has a large involvement in a number of experiments at JLab. We have provided leadership in the HERMES experiment at DESY, but have recently scaled down our efforts in order to focus on building BLAST at Bates. The group expects to maintain a strong presence at Bates through the "BLAST era," while continuing to do research elsewhere (at JLab in particular) so as to be able to make a smooth transition in the event of the closure of Bates.

   The research activities in relativistic heavy-ion physics are conducted entirely off campus, in the past at CERN and the AGS and presently at RHIC.

4. MIT has had and continues to have a large number of very good graduate students. The presence of Bates as an on-campus facility has been important in attracting students to MIT and to nuclear physics. However, both theory and experiment have suffered from a perception of diminished luster of the field. Moreover, as the number of university facilities decreases it becomes increasingly difficult to find qualified undergraduates with interest and/or previous experience in nuclear physics. However, our "system" of offering a prospective (experimental) student a Research Assistantship in LNS as a whole helps: often, a student who comes to MIT with the intention of doing high-energy physics will change his/her mind after learning of the opportunities in nuclear physics. On the negative side, MIT has fewer graduate fellowships than at least some of our peer institutions. A highly-qualified student whom we've admitted with a Research Assistantship or a Teaching Assistantship will often be lured away by a Fellowship offer from one of our competitors.

5. The nuclear physics program at MIT is one of the strongest in the Department of Physics, representing about 20% of the Departmental faculty. LNS enjoys strong institutional support from MIT – from the School of Science and from higher levels within the Administration.

   MIT has played a major role in the education of young scientists in nuclear theory and experiment. Since 1994, 89 graduate students, 82 undergraduates, and 51 postdocs have participated in the program, and 44 Ph.D. and 10 S.M. degrees have been awarded. Many of our former students are now on the faculties of universities and colleges and on the scientific staffs of the national laboratories. If adequate support of our programs is maintained, I am confident that we will continue to produce the future leaders of our field.